The habitat value of Gorse *Ulex europaeus* L. and Hawthorn *Crataegus monogyna* Jacq. for birds in Quarry Hills Bushland Park, Victoria

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Abstract

Weeds are one of the primary threats to biodiversity; however, their impacts on wildlife can vary. This research investigated the habitat value of Gorse *Ulex europaeus* L. and Hawthorn *Crataegus monogyna* Jacq. and the impacts of its removal on birds in a bushland park in Victoria. The area search method was used to survey birds in vegetation dominated by these two weeds, in native vegetation and in areas where a weed removal program was undertaken; this included revegetated areas. The highest bird species richness and abundance was found in sites dominated by the weeds. At sites where the weed removal program was in the early stages, a much lower species richness and abundance occurred. The final stage of the weed removal program, where revegetated areas were older than five years, supported high richness and abundance of birds, but not as high as that of sites dominated by the weeds; nor was the composition the same. Thus, even after five years, revegetation may not provide for the bird community that was originally supported by weeds. This is an important weed management consideration in this park, and should be for weed removal projects elsewhere. (*The Victorian Naturalist* **127** (4) 2010, 115-124)

Keywords: 'habitat value', Gorse, Hawthorn, birds, bushland

Introduction

It has been acknowledged widely that invasive plants (hereinafter weeds) are one of the primary threats to biodiversity conservation (Rodriguez 2006; Bremner and Park 2007; Funk and Vitousek 2007). Extensive research has focused on the ecology and biology of weeds, and the methods that are best for their control (Gosper 2004). Most studies focused on the negative effects that weeds have on native ecosystems, for example, their ability to outcompete and displace native vegetation (Randall 1996), and to change soil properties (Evans *et al.* 2001), fuel loads (Shafroth *et al.* 2005) and water regimes (Griffin *et al.* 1989). Studies that have considered the effects of weeds on wildlife reveal a different story (Gosper 2004).

Superb Fairywrens *Malurus cyaneus* in South Australia benefit from invasions of Blackberries *Rubus fruticosus* L., having higher nest success rates when nesting in Blackberry vegetation compared to surrounding native vegetation (Nias 1986). In addition, Boxthorn *Lycium ferocissimum* Miers provides a range of woodland birds with a fruit source (Peter 2000), and the endangered Orange-bellied Parrot *Neophema chrysogaster* supplements its winter food source with seeds from weed species (Loyn and French 1991). Overseas, weeds also have a variable impact on birds. Some invasions provide important habitat for birds (for example Sogge *et al.* 2008) but, in others, there is a loss of species diversity (Ceia *et al.* 2009).

The variable nature of this issue indicates the importance of research in this area. It is clear that in some situations weeds can provide valuable resources; however, research on this topic and the effects of weed removal on bird populations, is lacking. This study, therefore, had two aims (1) to investigate the habitat value of weeds for birds and (2) to investigate the effects of a weed removal program on birds.

Method

Study area

Study sites were located within Quarry Hills Bushland Park, 22 km NNE of Melbourne in the Victorian Volcanic Plains Bioregion. Declared in 2002, the park encompasses a hillside which surrounds the new housing development of Mill Park. Previously, it was used as pasture for farming, thus the vegetation is substantially different from that of pre-European settlement. Originally the vegetation was a mixture of Manna Gum *Eucalyptus viminalis* Labill. and Yellow Box *Eucalyptus melliodora* A.Cunn. ex Schuaer woodland, with Red Gum *Eucalyptus camaldulensis* Dehnh. woodland at lower elevations. Now the vegetation is dominated by large Gorse *Ulex europaeus* and Hawthorn *Crataegus monogyna* infestations and large patches of

Kangaroo Thorn *Acacia paradoxa* D.C. - a remnant native species. The remainder of the park consisted of mixed native and exotic grassland and areas of revegetation.

The management program for Gorse and Hawthorn in the park involved cutting and painting (cutting down individual plants and painting the resulting stumps with herbicide), mechanical removal, and the use of fire. In some cases, Gorse and Hawthorn that had been cut down, or mechanically removed, were left in piles so that some structure was left in place for birds and other wildlife that may have been using the weeds before their removal. Areas were then revegetated with a mixture of *Eucalyptus* and *Acacia* species.

Study sites

Five replicate study sites of 2500 m^2 were established in each of eight different habitat types found throughout the park. The habitat types consisted of four vegetation types and four sites at various stages along a weed removal program.

The four main vegetation types consisted of (1) Gorse dominated vegetation where at least 40% of the area was covered by shrubs, and 90% of these shrubs were Gorse; (2) Hawthorn dominated vegetation where at least 40% of the area was covered by shrubs, and 90% of these shrubs were Hawthorn; (3) Kangaroo Thorn dominated vegetation where at least 40% of the area was covered by shrubs, and 90% of these shrubs were Kangaroo Thorn; and (4) grassland with no trees or shrubs, where 70% of the vegetation present was native. The Gorse and the Hawthorn dominated vegetation were the weed components of the study, and the Kangaroo Thorn and grassland were the native comparisons.

The four weed removal stages of the park were areas that had been (1) cleared of either Gorse or Hawthorn; (2) cleared areas where removed Gorse or Hawthorn had been left in 'discard piles'; (3) young revegetated areas, where Gorse and Hawthorn had been removed and then revegetated with natives up to three years ago and; (4) old revegetated areas, where planting took place over five years ago. These weed removal stages represented the successive stages (1-4) of the weed removal program that occurred throughout the park.

Habitat variables

The composition and structure of vegetation was measured in 10m x 10 m quadrats in each site in each habitat type. All plant species present were recorded and their percentage cover was estimated. The number of mature trees and the number of logs greater than 10 cm in diameter were counted. A log was defined by Parkes *et al.* (2003) as fallen timber clearly separated from its parent tree and having a lower diameter limit of 10 cm. Also included were tree stumps up to 50 cm in height (Parkes *et al.* 2003). The percentage cover of the different strata in each quadrat was determined (Table 1). Structure was measured by placing a structure pole in the four corners of the quadrat and counting the number of vegetation 'hits' every 10 cm along the pole up to 1.5 m in height. An average was then determined for each site.

Bird Surveys

A total of 120 surveys were conducted. Surveys occurred during early winter, mid winter and early spring of 2007. The 'active timed area search' method of Loyn (1986) was adapted according to species area curves conducted, thus 30 minute surveys were carried out in the sites. This allowed for the most thorough search for each site. Surveys were carried out between sunrise and the subsequent four hours, when birds are most active and thus more conspicuous (Sutherland 1996). Surveys were conducted only on fine, calm days, as rain and wind have unfavourable effects on bird activity (White *et al.* 2005) and thus make surveys inconsistent.

For each survey, the species of bird present and the abundance of each species were recorded. Abundance was recorded conservatively, thus abundances throughout this study should

Table 1. Strata for which percentage cover was determined.

Habitat variable	Description
Grass	Cover of standing grasses, including sedges
Herbs	Vegetative ground cover other than grasses, including bryophytes
Shrubs	Woody plants up to 4 m high
Tree canopy	Crown cover of trees (woody plants greater than 4 m high)
Litter cover	Leaf litter and fallen dead vegetation including grasses and branches
Bare ground	Soil and rock not covered in vegetation or litter

be recognised as relative abundances, not actual abundance. Birds flying overhead were not included in the surveys.

Statistical Analysis

Abundance and richness of birds from the three different times of year were pooled and their averages used throughout all analyses. To determine differences in bird species richness and abundance between habitat types, a one way ANOVA was used after $\log_{10}$ and square root transformations. This was followed by an SNK test to highlight where these differences lay.

A Bray-Curtis similarity index was used to assess differences in the composition of plant and bird species between habitats. Sites that recorded no birds were excluded from the analysis of bird composition. Significant differences in composition between habitat types were identified and compared using ANOSIM (analysis of similarities). SIMPER (similarity percentage) was used to reveal which species were characteristic of a habitat type and also those that contributed most to dissimilarities between habitats. Finally, multi-dimensional scaling (MDS) generated an ordination of the similarities of the plant and bird communities (Bray-Curtis similarity) between habitats.

Results

Habitat variables

Plant species composition between the habitat types differed significantly (ANOSIM) as none of the 999 random permutations exceeded the global R statistic (R=0.537). However, MDS revealed that there was a lot of overlap between the sites of the different habitat types. With MDS, the four vegetation types were generally distinct from each other based on plant species percentage cover; however, sites from the different weed removal stages did not separate (Fig. 1). Cleared sites and sites from both revegetation stages tended to be closer to grassland sites, while discard piles had a plant composition more similar to both weed dominated vegetation types.

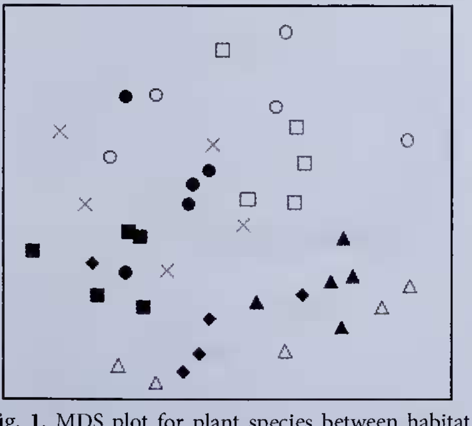

Fig. 1. MDS plot for plant species between habitat types based on group average clustering from Bray-Curtis similarity matrix on percentage cover (square root transformed) data (where ◆ = Gorse, ▲ = Hawthorn, ■ = Kangaroo Thorn, ● = Grassland, O = Old Revegetation, □ = Young Revegetation, X = Cleared and Δ = Discard Piles).

The vertical vegetation structure between the habitat types also was different. All habitat types were most dense below 10 cm in height (Fig. 2). Gorse, Hawthorn and Kangaroo Thorn dominated vegetation had a similar structural complexity. There was no structural complexity above one metre for discard piles, grassland, cleared sites and young revegetation (Fig. 2). Old revegetation showed structural complexity above one metre; however, this generally was more sparse than Gorse, Hawthorn and Kangaroo Thorn dominated vegetation (Fig. 2).

On average, all habitat types had a higher cover of grass compared to herbs (Table 2). Gorse dominated vegetation had the greatest average shrub cover, while Hawthorn dominated vegetation was the only habitat with any tree canopy (Table 2).

Bird community

A total of 34 bird species were recorded across the eight habitat types, but no species was recorded across every habitat type (Table 3). The Superb Fairywren was most widespread, found in the greatest number of sites and 75% of habitats (Table 3). Hawthorn dominated vegetation had the highest relative abundance of birds and the highest species richness (Table 3). Six introduced bird species were recorded across the park. While the two weed dominated habitats had the highest richness of introduced birds (Table 3), introduced bird species made up a similar proportion of the bird richness in each habitat (from 13-26%), excluding grassland, which had no introduced species (Table 4).

There were significant differences in both bird species richness ($F_{7,32}$=7.890, p<0.001) and abundance ($F_{7,32}$=4.893, p=0.001) between habitat types. Hawthorn, Gorse and Kangaroo Thorn dominated vegetation had significantly higher species richness compared to grassland, cleared sites, young revegetation and discard piles (SNK<0.05) (Fig. 3). Old revegetation had similar richness to all habitat types except

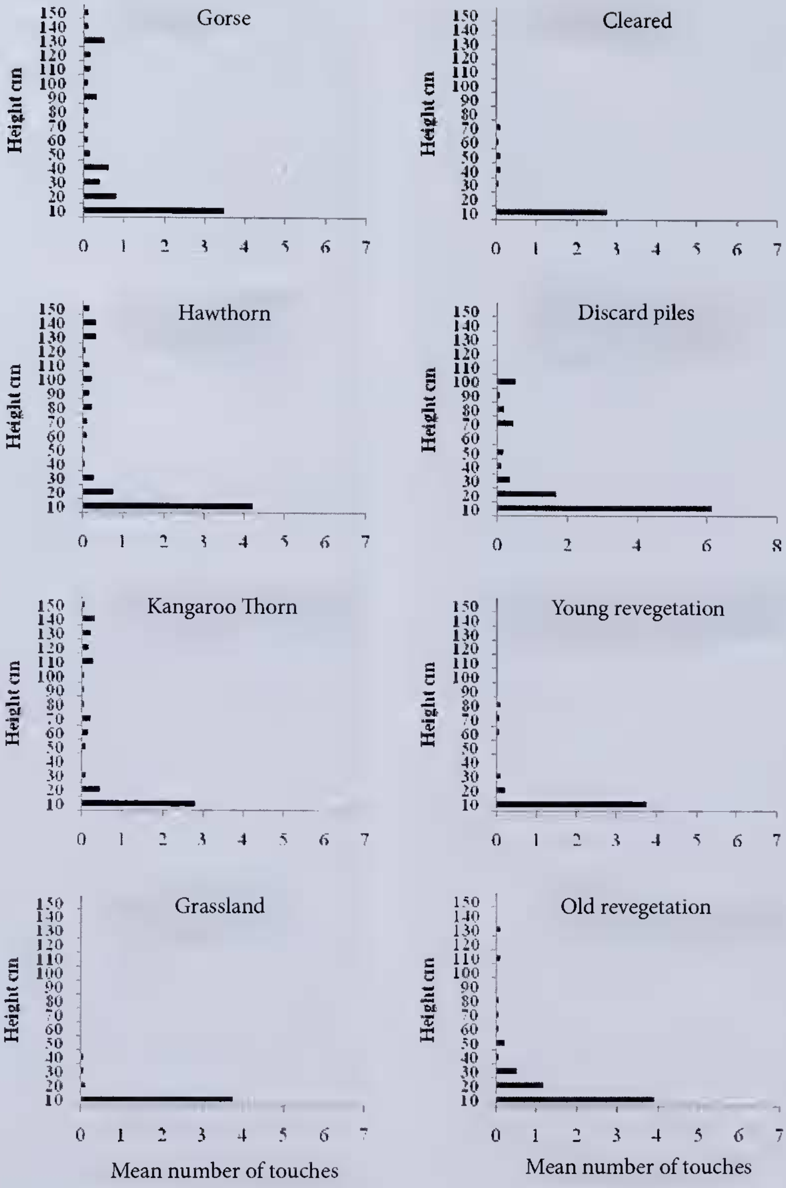

Fig. 2. Vegetation structure derived from structure pole measurements (average number of touches per 10 cm section of a 150 cm pole) of different habitat types.

young revegetation, which had significantly lower bird richness (SNK p<0.05). In comparison, Hawthorn dominated vegetation had a higher average abundance of birds compared to grassland, young revegetation, cleared areas and discard piles (SNK p<0.05), while old revegetation, Gorse and Kangaroo Thorn dominated vegetation all had similarly high abundances that were not significantly different from any of the other habitats (SNK p>0.05) (Fig. 4).

Based on Bray-Curtis similarity indices, there was a significant difference in bird composition

Table 2. Average cover (%) of strata of habitat types in Quarry Hills Bushland Park

Strata	Gorse	Hawthorn	Kangaroo Thorn	Grassland	Cleared	Discard piles	Young revegetation	Old revegetation
Grass	18	90	78	86	66	42	78	60
Herb	9	24	1	8	6	21	12	9
Shrub	82	40	64	0	12	0	36	10
Tree canopy	0	6	0	0	0	0	0	0
Leaf litter	11	9	20	11	8	0	4	1
Bare ground	3	8	18	3	14	0	6	22

between the different habitats ($p<0.05$), derived from bird abundance data (ANOSIM), as none of the 999 random permutations exceeded the global R statistic ($R=0.457$). Multi-dimensional Scaling ordination revealed that almost all sites had differences in composition; however, MDS also displayed some clustering of habitat types. Gorse, Hawthorn and Kangaroo Thorn dominated vegetation sites generally clustered closely together, yet they tended to be separate from young revegetation, some cleared sites and grassland sites which clustered together (Fig. 4). Discard pile sites were closer to the weed and Kangaroo Thorn vegetation types. Many of the old revegetation sites were found closest to Kangaroo Thorn sites, but also appeared to 'bridge the gap' between the cluster of the weed and Kangaroo Thorn habitats and the young revegetation, grassland and some cleared sites (Fig. 4).

Grassland sites were the only habitat with all sites distinctly separate from other habitat types (Fig. 4), and the presence of the Australasian Pipit *Anthus novaeseelandiae* contributed the most to this dissimilarity (SIMPER). The presence of the Common Starling *Sturnus vulgaris* was the main contributing factor to the dissimilarity between Hawthorn dominated sites and all other habitats (SIMPER). Yellow-rumped Thornbills *Acanthiza chrysorrhoa* were a typical species found in both Kangaroo Thorn and old revegetation, and their presence in these habitats contributed most often to the dissimilarity between other habitat types (SIMPER).

Discussion

The value of weeds for birds

Introduced vegetation, such as Gorse and Hawthorn, becomes important to birds when it provides more cover or food than remaining native vegetation (Loyn and French 1991). This is indicated when a consistent or more concentrated use of introduced vegetation, compared to adjacent native vegetation, is observed (Loyn and French 1991). Based on their similarly high bird richness and abundance compared to the remnant Kangaroo Thorn dominated vegetation, Gorse and Hawthorn dominated areas should thus be considered important vegetation for birds in Quarry Hills. Grassland areas had much lower species richness and abundance than the former habitat types; however, these sites displayed the most distinct composition, highlighting their importance to the overall bird community at Quarry Hills.

The similar richness and abundance of birds in the two weed dominated vegetation types and the Kangaroo Thorn dominated vegetation also was displayed with bird composition. This pattern was reflected in the vertical structure of the vegetation types, where the weed and Kangaroo Thorn dominated vegetation types were clearly more structurally complex, above 50 cm, than grassland. This also was supported by the fact that vegetation types tended to separate into distinct plant communities, but not bird communities. If the cover of a weed was an important factor in determining bird composition it would be expected that the vegetation types would have clustered similarly based on plant species cover and bird abundance with MDS.

The higher richness and abundance of birds in weed dominated vegetation in this park differs from other studies, which have found significantly lower overall species richness in weed sites compared to native sites (Daniels and Kirkpatrick 2006; Scott Mills *et al.* 1989). The similar proportions of introduced and native birds in both weed and native dominated habitats also differed from previous studies, which have found that introduced bird species often are strongly associated with introduced plant species (White *et al.* 2005). Clearly the classification of a plant into 'weed' or 'native' is not a determinant of the diversity or composition of a bird community.

There is a range of other influences that can be a factor in the structure of a bird community. The size, colour, quantity and timing of

Table 3. Bird species of Quarry Hills Bushland Park. Numbers in bold represent the number of sites each bird species occurred in (maximum = 5), pooling time of year. This is followed by the average abundance of each species, pooling time of year.

Common	Scientific	Grassland	Cleared	Young revegetation	Discard piles	Old revegetation	Kangaroo Thorn	Gorse	Hawthorn	Total
Australian Magpie	*Cracticus tibicen*	**1** 0.067	**2** 0.667	**3** 0.733				**2** 0.267	**4** 0.533	**12** 2.267
Australian Raven	*Corvus coronoides*		**1** 0.067				**1** 0.067		**1** 0.133	**3** 0.267
Australasian Pipit	*Anthus novaeseelandiae*	**5** 0.867		**1** 0.067		**1** 0.067				**7** 1.000
Welcome Swallow	*Hirundo neoxena*	**3** 0.733				**3** 1.133				**6** 1.867
Yellow Rumped Thornbill	*Acanthiza chrysorrhoa*		**1** 0.533	**1** 0.200		**4** 1.400	**4** 1.400	**1** 0.067	**3** 0.867	**14** 4.466
Spotted Dove*	*Streptopelia chinesis*		**1** 0.133				**1** 0.133	**1** 0.067	**2** 0.333	**5** 0.667
Grey Butcherbird	*Cracticus torquatus*		**1** 0.067	**1** 0.067		**1** 0.067				**3** 0.200
Superb Fairywren	*Malurus cyaneus*		**2** 0.2		**3** 0.600	**3** 0.600	**4** 0.800	**4** 0.867	**4** 0.800	**20** 3.867
New Holland Honeyeater	*Phylidonyris novaehollandiae*			**1** 0.133	**1** 0.067		**1** 0.133	**3** 0.467	**3** 0.333	**9** 1.133
White-browed Scrubwren	*Sericornis frontalis*				**1** 0.067			**3** 0.533		**4** 0.600
Common Starling*	*Sturnus vulgaris*			**1** 0.200	**1** 0.067	**2** 0.600		**2** 0.467	**3** 2.267	**9** 3.600
European Goldfinch*	*Carduelis carduelis*			**1** 0.067			**2** 0.200	**2** 0.800	**2** 0.600	**7** 1.667
Eastern Rosella	*Platycercus eximius*			**1** 0.4	**1** 0.067	**1** 0.067	**1** 0.067		**3** 0.867	**7** 1.466
Red Wattlebird	*Anthochaera carunculata*			**1** 0.2	**1** 0.067	**2** 0.467				**4** 0.733
Crimson Rosella	*Platycercus elegans*				**1** 0.133			**2** 0.333	**2** 0.333	**5** 0.800
Black bird*	*Turdus merula*				**1** 0.067		**3** 0.400	**3** 0.333	**4** 0.467	**11** 1.267
Red-browed Finch	*Neochmia temporalis*				**1** 0.133			**2** 0.267	**1** 0.200	**4** 0.600
Common Myna*	*Sturnus tristis*				**1** 0.267					**1** 0.267
Striated Thornbill	*Acanthiza lineata*					**1** 0.133	**2** 0.333	**2** 0.200	**1** 0.133	**6** 0.800
Common Greenfinch*	*Chloris chloris*					**1** 0.133		**1** 0.133	**2** 0.267	**4** 0.534
Silvereye	*Zosterops lateralis*					**1** 0.133	**3** 0.600	**1** 0.133	**1** 0.200	**6** 1.067
Grey Fantail	*Rhipidura albiscapa*					**1** 0.133	**2** 0.133	**1** 0.067	**1** 0.133	**5** 0.467
Brown Thornbill	*Acanthiza pusilla*					**1** 0.067	**3** 0.267	**3** 0.533	**3** 0.200	**10** 1.066
Spotted Pardalote	*Pardalotus punctatus*					**1** 0.067				**1** 0.067
Striated Pardalote	*Pardalotus striatus*					**1** 0.067				**1** 0.067
Horsfield's Bronze-Cuckoo	*Chalcites basalis*						**1** 0.067		**2** 0.267	**3** 0.333
White-plumed Honeyeater	*Lichenostomus penicillatus*						**1** 0.067		**2** 0.133	**3** 0.200
Scarlet Robin	*Petroica boodang*						**1** 0.133			**1** 0.133
Grey Shrike-thrush	*Colluricincla harmonica*							**1** 0.067		**1** 0.067
Common Bronzewing	*Phaps chalcoptera*							**1** 0.333		**1** 0.333
Tawny Crowned Honeyeater	*Glyciphila melanops*							**1** 0.067		**1** 0.067
Eastern Spinebill	*Acanthorhynchus tenuirostris*								**1** 0.067	**1** 0.067
Magpie-lark	*Grallina cyanoleuca*								**1** 0.067	**1** 0.067
Straw-necked Ibis	*Threskiornis spinicollis*								**1** 0.067	**1** 0.067
Total introduced bird species (richness and abundance)		**0** 0	**1** 0.133	**2** 0.267	**3** 0.400	**2** 0.733	**3** 0.733	**5** 1.8	**5** 3.933	
Total native bird species (richness and abundance)		**3** 1.667	**5** 1.533	**7** 1.8	**7** 1.133	**13** 4.400	**12** 4.066	**14** 4.000	**17** 5.333	
Total bird species (richness and abundance)		**3** 1.667	**6** 1.667	**9** 2.067	**10** 1.533	**15** 5.133	**15** 4.800	**19** 5.800	**22** 9.266	

Table 4. Species richness of birds and percentage of native and introduced bird species in habitats of Quarry Hills Bushland Park.

Habitat type	Total bird richness	Native species (%)	Introduced species (%)
Hawthorn	23	78	22
Gorse	19	74	26
Kangaroo Thorn	15	80	20
Old revegetation	15	87	13
Discard pile	9	78	22
Young revegetation	8	75	25
Cleared	6	83	17
Grassland	3	100	0

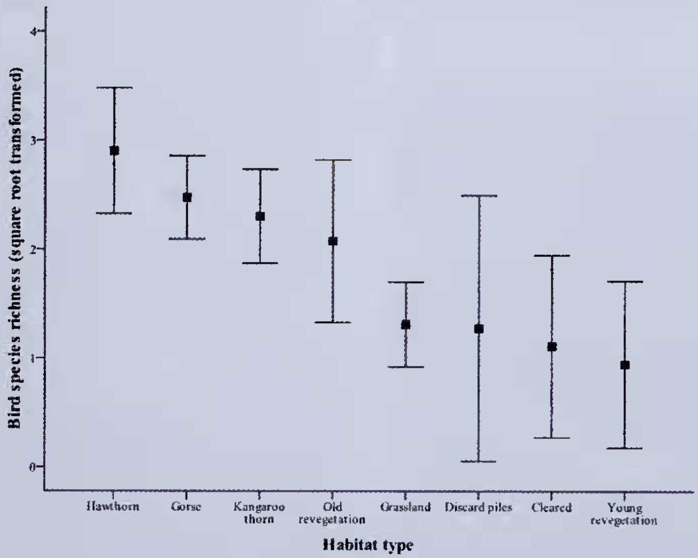

Fig. 3. Bird species richness between habitats (mean +/- 95% C.I.)

fruits can play a big role in the attraction of birds to an area. Frugivourus birds commonly select plants with fruits that are black or red; the colours of the fruits of a large number of weeds in Australia, including Hawthorn (Ford and Paton, 1986; Gosper and Vivian-Smith, 2006). Some birds have been found in higher abundances when fruits are prolifically available (Gosper 2004), while differences in invertebrate assemblages will influence insectivorous birds (French and Zubovic 1997). As well as foraging, bird communities will be influenced by the availability of perch sites, nesting sites and material, and shelter from the elements and predators (Cody 1985). The more structurally complex a habitat is, the greater the opportunity that the right combination of such factors will exist to suit a species. Hence, more niches are available for a greater diversity of species (Cody 1985). This clearly was the case with the two weed dominated vegetation types and the Kangaroo Thorn dominated vegetation type in Quarry Hills. The presence of a canopy in some Hawthorn dominated areas further added to the structural complexity of these sites, probably contributing to the higher bird diversity in these sites.

The effects of weed removal on birds

Weed removal had a negative effect on birds. This was displayed by the significantly lower richness of bird species in cleared sites, discard piles and young revegetation sites. While not significantly different consistently, bird abundance displayed a similar trend in these sites compared to the weed dominated vegetation. In addition, the difference in bird community composition between the two early stages of

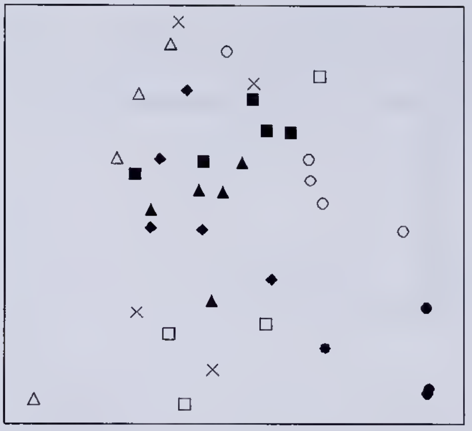

Fig. 4. MDS plot for bird species between habitat types based on group average clustering from Bray-Curtis similarity matrix on relative abundance (square root transformed) data (where ◆ = Gorse, ▲ = Hawthorn, ■ = Kangaroo Thorn, ● = Grassland, O = Old Revegetation, □ = Young Revegetation, X = Cleared and Δ = Discard Piles).

the weed removal program further demonstrates the severe effect that weed removal was having on the bird community. In comparison, areas of discard piles had similarly low species richness compared to cleared sites and young revegetation, yet the species composition was more similar to the weed sites. Thus, weed discard piles helped to serve their purpose, acting as a refuge for some bird species.

Old revegetation sites tended to bridge the gap between the sites of the two earliest stages of weed removal and the weed dominated vegetation in terms of bird richness, abundance and also composition; however, it is important to note that this was not equivalent to the weed dominated vegetation. Thus, even five years after revegetation, the resources that were lost with the removal of the weeds are not completely replaced.

The use of Eucalypt and Acacia species to revegetate the areas where weeds once were, may result in a permanent shift in bird composition, as eventually these species will grow into trees, and the resulting vegetation will have a very different structure from the current weed vegetation; however, because none of the bird species in the park were of conservation significance, this may not be of concern to management. In fact, the new structure provided by the old revegetation would likely reflect the original vegetation of the area, before it was cleared for farming. Thus, ultimately the weed removal and revegetation could have a desired outcome. In the meantime, there will be a net loss of birds due to the management program. Only continued studies will reveal how long it will take for a revegetated area to support a desirable bird community, and to determine which species will not be sustained.

Gosper and Vivien-Smith (2006) suggest that because of the time-lag, where native replacements are not providing resources made available by weeds, weed removal should be conducted over a period of time that is relative to its replacement. The results presented in this paper support this; thus, gradual removal and replacement is recommended. Quarry Hills Bushland Park provides a good example of this, demonstrating all stages of the weed removal program, along with significant areas where weed control has not been applied. Yet management plans in 2007 aimed to eradicate the park's weeds in eight years. Considering that it takes at least five years for revegetation to begin to support the birds, this action may not be appropriate if the current community is desired.

Implications

Quarry Hills is a highly disturbed and degraded site, with little surrounding vegetation to support bird species if the weeds are removed. The current amount of revegetation may provide enough to sustain a small proportion of the community in the meantime. As the areas of 'young revegetation' mature, it would be expected that more of the bird community will be supported as well; however, not all weed removal programs incorporate revegetation into their plans. In these areas it is likely that there will be substantial losses in abundance of birds and species when weeds are removed.

With increasing evidence that weeds are used as habitat, and habitat loss being a primary threat to birds (Beissinger 2000), the issue of weed removal becomes complicated. In Victoria, weeds on public land are managed to conserve indigenous biodiversity (Environmental Weeds Working Group 2007), yet if weeds are being used as habitat, their removal could be doing more harm than good for the diversity of fauna, at least in the short term. It is essential to better understand this issue so that weed removal has the desired outcomes for all biodiversity.

The consequences of weed removal would be very severe if the weeds were supporting an endangered or declining species. In New South Wales the Camphor Laurel *Cinnamomum camphora* L. a major weed, provides a winter food source for declining rainforest pigeons (Date *et al.* 1996). It has been suggested that a number of these pigeon species have since been saved from local extinction because of the fruits that the Camphor Laurel provides (Neilan *et al.* 2006). As a result there have been calls for the strategic retention of Camphor Laurel, as well as its eradication (Neilan *et al.* 2006).

This issue is not confined to birds. Weeds have been found to provide resources for amphibians (Bower *et al.* 2006), invertebrates (Yeates and Barmuta 1999), fish (Glover and Sagar 1994) and mammals (Christopherson and Morrison 2004; Lawrie 2001; Schmidt *et al.* 2009). In Victoria, the nationally endangered Southern Brown Bandicoot extensively uses Blackberry invasions along water courses as habitat (Schmidt *et al.* 2009).

Despite such critical findings, research on this issue is still lacking. The extent of species specific interactions with weeds is predominantly unknown, as are the consequences of weed removal. This means that weed managers have little information available on which to base their weed programs, with respect to wildlife. Lawrie (2001) suggested an audit system designed to identify whether animals are using weedy areas, in order to adapt weed management to best suit them. In practice, this system would be highly beneficial in helping managers to recognise when weeds are important, especially in the absence of current research. Unfortunately, it is unknown whether this type of system has been adopted. In fact, it is unknown how many weed managers actually take wildlife into account before weed removal at all, let alone how they go about it. Understanding the attitudes and actions of weed managers on this issue would be another important step in the process of creating best practice weed management with respect to wildlife.

Conclusion

The role that weeds may play in supporting bird communities can be very important and it should be a serious consideration when planning weed management programs. When weeds are found to be providing for birds, weed removal on its own is unlikely to be the best option. Gradual removal of weeds in conjunction with replacement is the best option if sustaining these communities is desired. However, it may take many years for replacement vegetation to mature to the age where it completely supports the bird community, and even then a different composition of species may arise. These considerations are all essential if weeds are being managed in the interests of biodiversity so that the potential consequences of weed removal are understood and removal can be adapted accordingly.

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Friend or foe: exotic flora and ecosystem function

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Abstract
Exotic flora, particularly weeds, are renowned for out-competing and displacing native flora, consequently affecting native fauna and pollinator relationships. Nonetheless, it stands to reason that weeds must provide some compensatory ecological value. This study assessed whether weeds are friend or foe to ecosystem function by considering the quality and quantity of pollen offered by widespread weeds in Australian ecosystems. Using the Honeybee *Apis mellifera* as a case study, and information derived from highly experienced commercial apiarists, we determined that 32 exotic plants are important pollen sources. Most species offered high to very high quality pollen. Pollen quality varied temporally, spatially and infraspecifically. Fifteen species were considered more beneficial to *A. mellifera* than others; only seven species were considered less beneficial. Thus, exotic flora contribute pollen resources that are valuable to maintain ecosystem function, particularly at times when flowering native species are few. (*The Victorian Naturalist* **127** (4) 2010, 124–136)

Keywords: exotic flora, weeds, ecosystem function, pollen, pollinators

Introduction
Exotic flora - globally - have a bad reputation. Their roll-call of maladies often includes out-competing and displacing native flora (e.g. Vitousek *et al.* 1987; Meiners *et al.* 2001; Levine *et al.* 2003) consequently affecting native fauna (Vitousek *et al.* 1987). Exotic species may interfere with native species further by affecting pollinator relationships, which can impact greatly on the ecology and evolution of native floral species (Ashman *et al.* 2004). We refer to those species most proficient at such maladies as weeds. Ubiquitous as weeds are, it stands to reason that they